Flower Bud Formation in Short-Day Strawberry Cultivar under Non-Photo Inductive Conditions

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Abstract

A scheme for producing short-day type strawberry cultivars that initiate flowers under long-day photoperiod was used to investigate the flower bud induction. When runner tips of short-day type 'Carmine' were started as plug plants in early July and field planted 1 September 86% of transplants flowered by mid October. When the July-plugged transplants were retained in tray flats at high plant density during July and August the leaves formed a full canopy or high leaf area index above the plant crowns and the crown near the base of leaf petioles was completely in the shade. A spectral analysis showed that wavelengths less than 700 nm did not reach the crown because of chlorophyll absorbance. Illuminating the crown for 16 h·day^{-1} for 4 weeks in August with 662 nm light decreased transplants that flowered by mid October. The results suggest that fall-flowering transplants of short-day strawberries were produced by rooting runner tips in early July and having a plant canopy that alters the quality of light that illuminates the crown.

INTRODUCTION

Fall-winter strawberry production in the mid-Atlantic coast region can be enhanced by combining the new technologies for containerized nursery (plug) plant production and a protected culture system. Short-day cultivars can be induced to flower early by growing transplants in artificial short-day and cool temperature conditions in late summer (Sonsteby and Hytonen, 2005; Verheul et al., 2006). Light is a critical environmental factor for plants. Where flower induction is regulated by daylength, the leaves are the primary recipient of the external signal that is transmitted to the meristem where the flowering response occurs (Salisbury and Ross, 1992). Light is absorbed by either the phytochrome (Phy) or cryptochrome (blue light) photosensors that promote the expression of genes that changes the fate of the apical meristem from vegetative growth to reproductive development (Amasino, 1996). Phytochrome undergoes a transformation between its red (P_r) and far-red (P_{fr}) forms and affect an oscillator that regulates downstream accumulation of products.

Recently, Takeda and Newell (2006a, b) reported a remarkably high fall reproductive capacity in July-plugged transplants of short-day 'Carmine' and 'Chandler' strawberry plants. These transplants were grown in a greenhouse with >20°C temperatures and long photoperiod in July and August, conditions generally not considered favorable for floral bud induction. Between 73 and 100% of transplants that were propagated in early July and established in the field on 1 September flowered by mid October and produced 310 g of fruit per plant by late December, but less than 30% of transplants rooted in early August flowered in November and December. The objective of the present work was to evaluate the effect of red (600-700 nm) light directed at the crown on fall on fall flowering in short-day strawberry 'Strawberry Festival'.

MATERIALS AND METHODS

On 1 July 2007, runner tips of 'Strawberry Festival' were plugged into 50 cell pack trays (~320 transplants·m^{-2}) and misted under intermittent sprinklers for 10 days to promote rooting. Afterwards, all trays were placed on a greenhouse bench and trays were watered several times each day and fertigated. From 1 August to 27 August, transplants were placed in a growth chamber (16h light with 600 µmole·m^{2}·sec^{-1} PAR using T8 triphosphore fluorescent lamps, 8h dark, constant 24°C and 65% RH). During the 27-day period in the growth chamber, 100 transplants in 2 trays were treated each day with red light emitting diode (LED) during the 16h light period. Red LED lamp (Holiday Creations, Inc., Littleton, CO; specifications of maximum wavelength at 662 nm, band width of 602 to 702 nm, total red (600-700 nm) output of 3.5 µmole·m^{-2} s^{-1}, and 80% of output in a 30 nm band between 644 and 674 nm) was placed 1 cm above the crown of 100 transplants in 2 flats. 100 transplants in 2 additional trays (control plants) did not receive supplemental red LED light treatment. On 29 August, all transplants were established in grow bags (Crop King, OH) with soilless media atop raised beds inside a high tunnel (15 m long × 7 m wide). We counted plants with open flowers in September, October and November 2007.

RESULTS AND DISCUSSION

To investigate the reasons that the strawberry plants initiate flower buds under conditions normally considered non-favorable for flower bud initiation, various changes to the propagation system were implemented. The leaves are thought to be the source of stimulatory or inhibitory signals that are transmitted to the apical meristem of a new bud where the cells are altered for reproductive development through Phy-mediated processes. It is likely that immature leaves in the bud or just emerged from the crown can also perceive light cues to evoke the apical meristem to become reproductive (Kerstetter and Hake, 1997).

Sunlight is rich in red light compared with the light under vegetation shade. The light, in case of the latter, is selectively depleted in red light because of a strong chlorophyll absorbance by the overlying canopy (Fig. 1). Perhaps a crown in a strongly shaded condition may show a shade-avoidance syndrome in response to far-red (700-750 nm) enriched light. We observed that when strawberry transplants are maintained in tray flats at high plant density (320 transplants·m^{2}), leaf area increases to form a dense canopy above the plant crowns. Spectrophotometric measurements showed that none of wavelengths less than 700 nm reached the crown because essentially all the shorter wavelength light was absorbed through photosynthesis or reflected back. In this situation, phototransformation of Phy pigment ($P_r \longleftrightarrow P_{fr}$) would be shifted to reduce the ratio of P_{fr} / P_r. In contrast, plants growing with wider space between them would allow sunlight to illuminate the crown directly. In addition, light could reflect off the ground between the plants which would shift Phy in the form of P_{fr} and maintain the apical meristem in vegetative growth.

In this study, supplemental red LED light (maximum peak at 662 nm) illumination of the crown (Fig. 2) during August reduced the number of transplants that flowered in October compared to transplants that were not lit with red LED lamps. Only 25% of transplants that were lit with red LED lamps bloomed by 3 October. Without the supplemental red LED light treatment, 38% of transplants bloomed by early October. By 24 October, 45% of transplants with their crowns lit with red LED lamps had open flowers compared to 75% of un-lit plants. Spectral composition of the irradiation directed at the crown during the day appears to quantitatively affect flower bud initiation. The results from this study suggest that the absence of red light irradiation on the crown promoted flower bud initiation.

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Figures

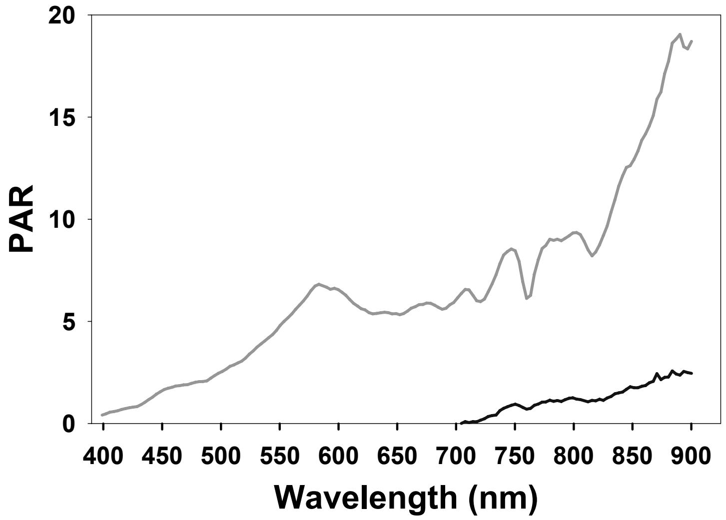

Fig. 1. Spectral response curves above and under the canopy. Top line represents spectral response above the canopy; and bottom line represents spectral response at crown level of 6-week-old transplants held at high density.

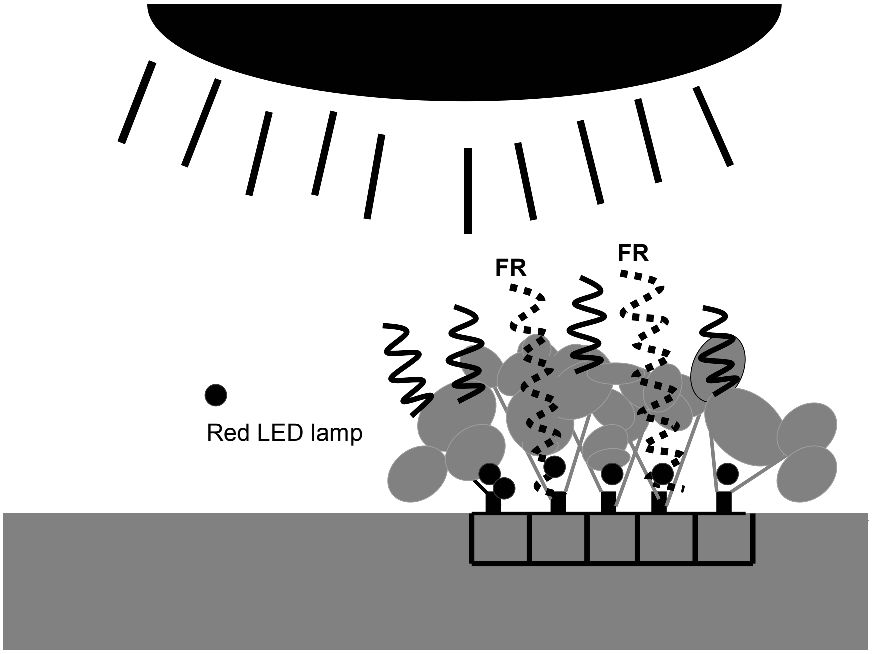

Fig. 2. Sunlight is rich in both red (R) and far red (FR) light. FR light is transmitted through the leaves, but when transplants are maintained at high density and have high leaf area index, the leaves absorb much of the photosynthetically active radiation incident on the leaf surface, including R light. Red LED lamps were placed directly above the crown.